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DECEMBER 1916

Phytopathology

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American Phytopathological Society

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THE OFFICIAL ORGAN OF

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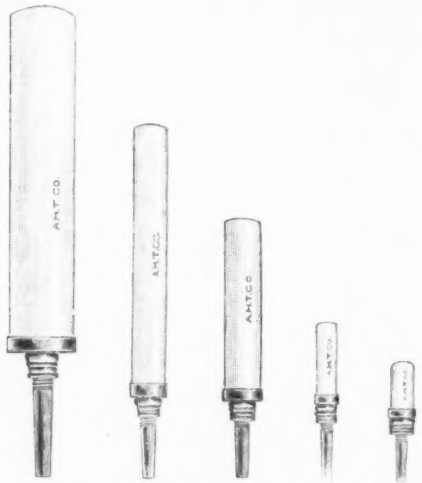

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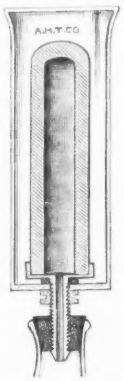

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PHYTOPATHOLOGY

VOLUME VI NUMBER 6

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STUDIES IN THE LIFE HISTORIES OF SOME SPECIES OF SEPTORIA OCCURRING ON RIBES

R. E. Stone

With Two Figures in the Text

SEPTORIA RIBIS DESM.

In a previous communication[1] it was stated that *Septoria ribis* Desm., occurring on *Ribes nigrum*, has for its perfect stage *Mycosphærella grossulariæ* (Fr.) Lindau.[2] The report was based largely on work done with the fungus as it occurs on the black currant. At the present time more evidence has accumulated on this fungus and the ones occurring on other species of Ribes which makes a further account advisable.

Septoria ribis Desm., was described in 1842 on material from *Ribes nigrum* and the name has since been applied to similar forms occurring on other species of Ribes. That *Mycosphærella grossulariæ* (Fr.) Lindau, is the perfect stage is shown by the following data: (1) *Mycosphærella grossulariæ* is found constantly upon old over-wintered leaves of *Ribes nigrum* following an attack of *Septoria ribis* Desm.; these observations have been made in the springs of 1913, 1914, 1915 and 1916. (2) If leaves infected with *Septoria ribis* are placed out of doors in wire baskets, they will bear, the following spring, *M. grossulariæ*. Leaves so infected were placed out doors in the autumns of 1913, 1914 and 1915. (3) If leaves bearing perithecia containing viable ascospores are included within moist chamber with a healthy currant plant and then sprayed, the green leaves, in ten days will show the typical spotting due to *Septoria ribis* and in twenty days will show typical pycnidia and spores. Experiments were tried in 1913, 1914, 1915, and 1916. (4) If single ascospores are planted in nutrient agar, each germinating ascospore will produce a colony having pycnidia and spores similar to *Septoria ribis* in pure culture as

[1] Stone, R. E. Perfect stage of Septoria ribis. Phytopath. **6**: 109. 1916.
[2] Lindau, G. Engler & Prantl's Nat. Fam. **1**[1]: 424.

TABLE 1

Record of single ascospore cultures of Mycosphærella grossulariæ

YEAR	NUMBER OF ASCOSPORES PLANTED	NUMBER OF ASCOSPORES GERMINATED	RESULT
1913	50	23	Pycnidia in 20 days
1914	71	40	Pycnidia in 23 days
1915	30	18	Pycnidia in 19 days
1916	15	12	Pycnidia in 24 days
Total.....	166	93	93 colonies of Septoria

obtained from spores of *Septoria ribis* direct (table 1). Furthermore, the Septoria so obtained is capable of infecting *Ribes nigrum* causing the typical leaf spots from which the Septoria may be isolated.

Pammel[3] has suggested that *Sphærella grossulariæ* (Fr.) Auserw. is the perfect stage of *Septoria ribis* Desm., or of *Cercospora angulata* Wint., but presents no proof further than the association of the ascomycete with over-wintered currant leaves.

As far as can be learned at the present time *Mycosphærella grossulariæ* (Fr.) Lindau, has been collected in America only on *Ribes nigrum* by Pammel, Iowa, 1891,[4] W. A. McCubbin, St. Catharines, Ontario, April, 1915, and by the author at Guelph, Ontario, April and May, 1913, April to July, 1914, April to June, 1915, April to June, 1916. In Europe there are records of *Mycosphærella grossulariæ* on *Ribes grossularia* (original host), *Ribes nigrum* and possibly *Ribes rubrum*.[5]

That the fungus attacking *Ribes nigrum* is the same as that on *R. grossularia* and *R. rubrum* is shown by inoculation experiments with both ascospores and conidia (table 2).

A careful examination of the literature and collections gives the following synonymy and description of the fungus:

Mycosphærella grossulariæ (Fr.) Lindau, Engler and Prantl, Nat. Pflanzenfam. **1′**: 424.

Sphæria grossulariæ Fr., Syst. Myc. **2**: 521.

Sphærella grossulariæ (Fr.) Auserw., Syn. Pyr. Eur., 11.

?Sphæria ribis Fckl., Sym. Myc., 108, Lille, p. 94.

Septoria ribis Desm., Mem. Soc. Sci., 1842.

Ascochy'a ribis Lib. Ex. No. 53.

Phleospora ribis West. Bull. Acad. Sci. Brux., 1850.

Septoria grossulariæ auct. not *S. grossulariæ* (Lib.) West.

[3] Pammel, L. H. Iowa Agr. Exp. Sta. Bul. 13: 67–70.

[4] Ellis & Everhart. North American Pycenomycetes, p. 266; Pammel, L. H Iowa Agr. Exp. Sta. Bul. 13: 67–70; Stevens, F. L. Fungi which cause plant diseases p. 245 and 519.

[5] Saccardo, P. A. Syl. Fung. **1**: 486.

Perithecia mainly hypophyllous, somewhat gregarious, spherical, 60–105 μ diam., with a small papilliform osteolum, black; asci, eight-spored, short pedicellate, clavate to cylindrical, 50 to 60 x 8 to 14 μ; without paraphyses; ascospores slender, straight or slightly curved, 1-septate, each cell biguttulate until near maturity, hyaline, 28 to 35 x 3 to 4 μ, tending to appear in sets of 4 in the ascus. On dead over-wintered leaves of currant and gooseberry following *Septoria ribis* Desm.

Pycnidia mainly hypophyllous, sometimes amphigenous, variable in size, brownish black, spherical; conidia elongated, 2- to 3-septate, hyaline

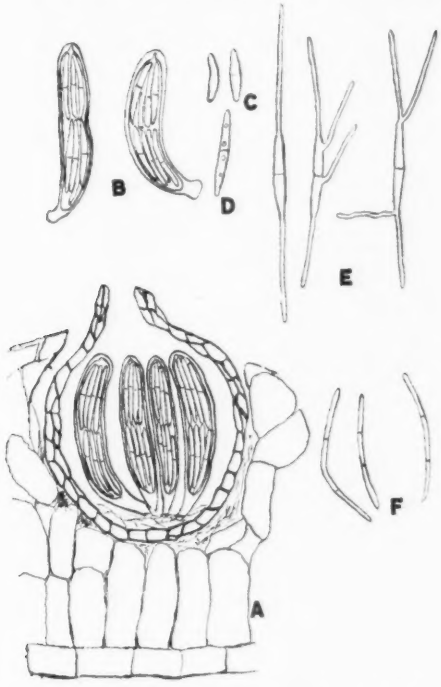

FIG. 1. Mycosphærella grossulariæ (Fr.) Lindau. × 280. *A*, perithecium containing asci; *B*, asci; *C*, young ascospores; *D*, mature ascospore; *E*, germinating ascospores; *F*, spores of Septoria ribis Desm.

40 to 50 x 1 to 2 μ. Spots hypophyllous, dark ashy gray with a distinct margin, angular or oval.

Hosts—*Ribes nigrum*, *R. rubrum*, *R. grossularia*, *R. cynosbati*; also reported on *R. prostratum*, *R. rotundifolia*, *R. bracteosum*, *R. divaricata* (?).

In the synonymy *S. ribis* Fckl., has been included provisionally because *R. rubrum* is a host for *Septoria ribis* and because of certain discrepancies in Fückel's original description which make his measurements

TABLE 2

Inoculation experiments with Mycosphærella grossulariæ

INOCULUM AND SOURCE	DATE	TRIAL HOST	RESULT
Ascospores from R. nigrum	May 31, 1915	R. nigrum	Spots June 18, pycnidia June 24
Ascospores from R. nigrum	May 31, 1915	R. rubrum	Spots June 18, pycnidia June 24
Ascospores from R. nigrum	May 31, 1915	R. grossularia	Spots June 18, pycnidia June 24
Ascospores from R. nigrum	May 31, 1915	R. oxycanthoides	Spots June 18, pycnidia
Ascospores from R. nigrum	May 3, 1916	R. nigrum	Spots May 25, pycnidia May 30
Ascospores from R. nigrum	May 31, 1915	R. aureum	
Ascospores from R. nigrum	May 3, 1916	R. aureum	
Septoria from R. nigrum	Aug. 10, 1915	R. nigrum	Spots Sept. 1, pycnidia Sept. 7
Septoria from R. nigrum	Aug. 10, 1915	R. grossularia	Spots Sept. 1, pycnidia Sept. 8
Septoria from R. nigrum	Aug. 10, 1915	R. rubrum	Spots Sept. 1, pycnidia Sept. 9
Septoria from R. nigrum	Aug. 10, 1915	R. aureum	
Septoria from R. nigrum	July 22, 1916	R. nigrum	Spots Aug. 6, 1916, pycnidia Aug. 10
Septoria from R. nigrum	July 22, 1916	R. rubrum	Spots Aug. 6, 1916, pycnidia Aug. 10
Septoria from R. nigrum	July 22, 1916	R. grossularia	Spots Aug. 6, 1916, pycnidia Aug. 10
Septoria from R. nigrum	July 22, 1916	R. oxycanthoides	Spots Aug. 6, 1916, pycnidia Aug. 10
Septoria from R. nigrum	July 22, 1916	R. aureum	

untrustworthy and because the thickness of the ascus wall would indicate that he was dealing with an immature ascus. Under such conditions the fungus might well conform to *M. grossulariæ* (Fr.) Lindau.[6]

Septoria grossulariæ auct., is included in the synonymy because many of the numbers so marked in American exsiccati agree with *S. ribis* Desm., in spore measurements besides occurring on a host of that fungus,[7] and do not at all agree with *S. grossulariæ* (Lib.) West., which has spores measuring 16 by 1 μ.

SEPTORIA AUREA E. & E.

In 1893 Ellis & Everhart described the Septoria occurring on *Ribes aureum* as a new species, *S. aurea*.[8] They also described a variety on the same host as *S. aurea* var. *destruens*, differing from the type by having longer spores.

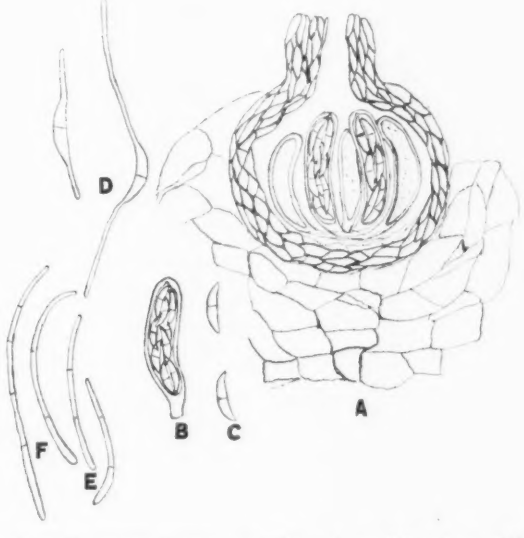

FIG. 2. Mycosphærella aurea Stone. × 280. *A*, perithecium with asci; *B*, ascus; *C*, ascospores; *D*, germinating ascospores; *E*, summer spores of Septoria aurea E. & E.; *F*, spores from a winter pycnidium.

Septoria aurea E. & E. is the cause of a leaf spot on *Ribes aureum* Pursh. The spots are first noticed in June and continue until the leaves are shed in the autumn. The spots are oval or round, light brown in color with

[6] Fückel. Symb. Myc. Eur., p. 108.

[7] Seymour and Earle. Economic Fungi, 473; Ellis & Everhart. Fungi Columbiani, 845. 2172; Ellis & Everhart. North American Fungi, 3373, 11480; Ellis & Everhart. Fungi Columbiani, 4478, on *Ribes lacustre* may be another species.

[8] Saccardo, P. A. Syl. Fung. **11**: 541.

a distinct, darker brown margin. The spots are 3 to 10 millimeters in diameter, sometimes confluent. Pycnidia amphigenous, 80 to 120 μ in diameter, walls thin. Early in the season the spores are comparatively small being 30 to 55 by 1.5 to 2 μ, but later in the season, especially after dry weather, the spores may measure, up to 75 by 2 to 2.25 μ. The form with the larger spores was described as *S. aurea* var. *destruens* E. & E.

After the fall of the leaves the fungus continues development and very generally passes the winter in the imperfect stage. The old leaves become more or less blackened and bear, generally on the under surface, numerous black thick-walled pycnidia. These pycnidia are 100 to 160 μ in diameter. The walls are 25 to 30 μ in thickness and are composed of numerous layers of cells. The spores are hyaline, measure 70 to 115 by 2 to 3 μ and are 3- to 5-septate.

The perfect stage

The old leaves also bear an ascomycete of the Mycosphærella type which by inoculation (table 3), and by pure culture (table 4), has been shown to be the perfect stage. As this stage apparently has not been described the following name is proposed and a description appended.

Mycosphaerella aurea n. sp.[9]

Syn. *Septoria aurea* E. and E.
Septoria aurea var. *destruens* E. and E.
Exs. Ellis and Everhart, North American Fungi, 2844.
Ellis and Everhart, Fungi Columbiani, '844, 1779.
Seymour and Earle, Economic Fungi, 472.

Perithecia amphigenous, partially embedded in leaf tissue, globose, short, papilliform, black, 75 to 115 μ in diameter; walls pseudoparenchymatous, two or three layers of cells thick; without paraphyses; asci subclavate to cylindrical, short stipitate, eight-spored, 50 to 75 μ; ascospores hyaline, of two equal cells, fusoid, curved, pointed at each end, 18 to 24 by 3 to 4 μ, irregularly biseriate.

Pycnidia amphigenous on definite spots when occurring on living leaves, 80 to 120 μ in diameter; spores hyaline, 30 to 75 by 2 to 2.25 μ, 3- to 5-septate. Pycnidia, in winter condition, amphigenous, 100 to 160 μ in diameter, thick-walled; spores hyaline, 70 to 115 by 2 to 3 μ.

Perithecia appearing on old leaves of *Ribes aureum* Pursh. May to June.

Pycnidia appearing on living leaves of *R. aureum*. June to October, and also on old leaves in winter and spring until June.

[9] If Sphærella is considered *nomen conservandum* the combination should be *Sphærella aurea* n. sp.

Kansas, Wisconsin, New York, Ontario.

Type material deposited in Cryptogamic Herbarium of the New York Botanical Gardens, New York City, supplemental material in the National Herbarium at Washington, D. C.

Mycosphaerella aurea spec. nov.

Syn. Septoria aurea E. and E.
Syn. Septoria aurea var. *destruens* E. and E.
Exs. Ellis and Everhart: North American Fungi, 2844.
Ellis and Everhart: Fungi Columbiani, 844, 1779.
Seymour and Earle: Economic Fungi, 472.

Fungus ascophorus: Perithiciis amphigeniis, erumpentibus, gregariis, sphæropsoidiis, atris, ostiolo brevi atque pertuso; ascis brevissime stipitatis, subclavatis vel cylindratis, 50 to 75 x 12 to 14 μ, 8-sporidiis; sporidiis hyalinis, fusoidiis, curvatis, extremitate utraque acuta, 18 to 24 x 3 to 4 μ, non in medio constrictis, distichis.

Hab. in foliis emortuis Ribis aurei, Ontario, May–June, socii Septoria aurea E. & E.

Fungus imperfectus: In foliis vivis maculis, determinatis, amphigenis, rotundatis vel confluentibus, atrozonatis; picnidiis amphigenis, 80 to 120 μ in diam.; sporulis 30 to 75 x 2 to 2.25 μ, hyalinis, 3- 5-septatis. Picnidiis in foliis mortuis; in maculis amphigenis gregariis, atris, 100 to 160 μ; vallo 10 to 15 cellis crasso; spordulis hyalinis, 75 to 115 x 2.3 μ, 3- 5-septatis.

In foliis vivis Ribis aurei, May–Oct., Kansas, Wisconsin, New York, Ontario. In foliis mortuis Ribis aurei, Nov.–June, Ontario.

That *Mycosphærella aurea* Stone is the perfect stage of *Septoria aurea* E. & E. is indicated by the following data:

Mycosphærella aurea has been found only on old leaves of *Ribes aureum*, which had previously borne *Septoria aurea* in 1915 and in 1916.

Leaves of *R. aureum* bearing *S. aurea* placed out of doors in cages in 1915, developed *M. aurea* in spring of 1916.

The Septoria obtained from individual ascospores produced a dark compact colony with numerous closely aggregated pycnidia; spores hyaline, 30 to 60 by 2 μ, three to five-septate (table 4). The pycnidia mature in about twenty days. The Septoria is capable of infecting *R. aureum* but not *R. nigrum*, as was determined by inoculation experiments from cultures secured in 1915 and in 1916 (table 3).

To further determine the range of *Septoria aurea* a series of cross inoculations was performed with spores directly from the leaf spots on *Ribes aureum* (table 5).

TABLE 3

Inoculation experiments with Mycosphærella aurea

INOCULUM	DATE	TRIAL HOST	RESULT
Ascospore of M. aurea	May 10, 1915	R. aureum	Spots bearing pycnidia June 2
	May 10, 1915	R. nigrum	
	May 17, 1915	R. aureum	Spots and pycnidia June 10
	May 17, 1915	R. nigrum	
	May 15, 1916	R. aureum	Pycnidia June 4
	May 15, 1916	R. nigrum	
	May 15, 1916	R. rubrum	
	May 15, 1916	R. grossularia	
	May 15, 1916	R. cynosbati	

TABLE 4

Records of single ascospore cultures of Mycosphærella aurea

NUMBER OF ASCOSPORES PLANTED	DATE	NUMBER OF ASCOSPORES GERMINATED	RESULT
21	May 17, 1915	10	10 colonies Septoria
30	May 15, 1916	20	20 colonies Septoria

TABLE 5

Cross inoculation experiments with Mycosphærella aurea

SOURCE OF INOCULUM	TRIAL HOST	DATE	RESULT
R. aureum	R. aureum	July 6, 1916	Septoria July 20
	R. nigrum	July 6, 1916	
	R. rubrum	July 6, 1916	
	R. grossularia	July 6, 1916	
	R. cynosbati	July 6, 1916	

It is thus seen that *M. aurea* Stone, is the perfect stage of *Septoria aurea* E. & E., and that the fungus is limited in its range of hosts.

CONCLUSIONS

Mycosphærella grossulariæ (Fr.) Lindau is the perfect stage of *Septoria ribis* Desm.

The perfect stage has been reported on *Ribes grossularia* and *R. nigrum* in Europe and possibly on *Ribes rubrum*. In North America the perfect stage has been collected only on *Ribes nigrum*.

The imperfect stage has long been known as *Septoria ribis* and is known in Europe and North America. The following hosts are known from inocu-

lation experiments: *Ribes nigrum*, *R. grossularia*, *R. rubrum*, *R. cynosbati*. It has also been collected on the following hosts: *R. rotundifolia*, *R. prostratum*, *R. bracteosum* and *R. divaricata*.

Mycosphærella aurea Stone is the perfect stage of *Septoria aurea* E. & E. This fungus is more limited in its range being known only in North America on *Ribes aureum*.

Finally, the author wishes to thank those who have assisted in the work, especially Professors G. F. Atkinson and H. H. Whetzel of Cornell University, and Professor J. H. Faull of the University of Toronto for the use of their herbaria and libraries, and Dr. V. B. Stewart for help in looking up some of the literature.

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A METHOD FOR STUDYING THE HUMIDITY RELATIONS OF FUNGI IN CULTURE

NEIL E. STEVENS

Accurate studies of the temperature relations of certain fungi causing storage rots have been made by several investigators. The perhaps equally important question of their relation to air humidity or amount of evaporation has, on the other hand, been almost entirely neglected. This discrepancy is apparently due to the fact that reliable thermostats, at least for temperatures considerably above and below room temperature, are available in nearly all laboratories, and the thermometer furnishes a satisfactory means of temperature measurement. The control of air humidity in large chambers is, on the other hand, relatively difficult and expensive. The considerable recent literature discussing the rate of evaporation shows how leading authorities differ as to the best method of measuring this factor, and it is perhaps equally debatable whether any really accurate and satisfactory method of recording air humidity is available (10).

During investigations of the fungi causing decay of strawberries in transit and more recently in studying the rots of cranberries, the writer has made use of a method of maintaining known humidities in small chambers which is applicable to the study of fungi in culture or growing on small fruits.

The method used was suggested to the writer by Dr. Charles Thom, and published by him in 1915 (12: 304). No claim to originality is, of course, made by the writer. The method is, however, described somewhat fully, because it seems applicable to much wider use. The table represents a compilation from the most reliable sources, and since so far as could be learned it is nowhere available as a whole, is here published for the convenience of other investigators. In compiling this table and in locating the sources on which it is based the writer has had the advice and assistance of several physiologists and physicists, to all of whom he wishes to acknowledge his indebtedness.

METHOD

Briefly, the method consists in keeping the cultures of fungi or affected fruits in an atmosphere which is maintained at a constant humidity by exposure to aqueous solution of sulphuric acid of known specific gravity.[1]

[1] This method of maintaining a constant humidity has been employed by Curtis (3) in his studies of the insulating properties of hard rubber and other solid dielectrics. This writer published (3 : 367) a curve showing the relationship between

Other hygroscopic substances might be used to maintain a constant humidity but sulphuric acid is convenient to use and so slightly volatile that it apparently does not affect the growth of the fungus.

The specific gravity of the solution was determined with a hydrometer when the temperature of the acid was 0°C. This temperature was easily maintained by using ice in diluting the acid, as suggested by Hastings (8). In practice the writer has found it convenient to use Hempel desiccators as containers. This form of container permits of readily changing the acid without disturbing the cultures or fruit, while the acid is free from contamination by juice leaking from berries or other fruits.

TABLE

The table showing the approximate relative humidity and saturation deficit corresponding to aqueous solutions of sulphuric acid of various specific gravities is based on the best information available. All computations were made with the aid of Crelle's multiplication tables (2) and carried to the first decimal place. They are, therefore, not absolutely accurate to the last figure but are well within the limits of observational error and will be found satisfactory for experimental work.

The portion of the table which includes specific gravities from 1.00 to 1.30 was taken in part from the similar table published by Hastings (8) which in turn was based on the experimental work of Dieterici (5). The relative humidity for each specific gravity of acid was taken from Hastings' table and the vapor tension at 20° and 30°C. calculated, on the assumption that the relative humidity for a given specific gravity of acid remains the same at all climatic temperatures, by multiplying the relative humidity by the vapor pressure of water at the given temperature. The saturation deficit, of course, is the difference between the vapor pressure of water and of the solution. The column giving the percentage of H_2SO_4 in the solution was added from Castell-Evans' physico-chemical tables (1: 843 and 861).

The second section of the table, including specific gravities from 1.344 to 1.754 is based on the work of Sorel (11), whose table gives the tension of aqueous vapor emitted by aqueous solutions of sulphuric acid containing various percentages of H_2SO_4. His table with the addition of a column giving the specific gravity for each percentage of acid is reprinted in the Chemiker Kalender (11). In this portion of table 1 the saturation deficit and approximate relative humidity have been added from calculations.

the density of a sulphuric acid solution and the relative humidity which will be maintained by it in an inclosure. This curve corresponds approximately to data given in table 1.

Table showing approximate relative humidity, vapor pressure and saturation deficit at 20° and 30°C. for dilute sulphuric acid of various specific gravities

SPECIFIC GRAVITY	PERCENTAGE H_2SO_4 IN THE SOLUTION	APPROXIMATE RELATIVE HUMIDITY	VAPOR PRESSURE AT 20° C.	SATURATION DEFICIT AT 20° C.	VAPOR PRESSURE AT 30° C.	SATURATION DEFICIT AT 30° C.
		per cent	*mm. of mercury*		*mm. of mercury*	
1.00	Water	100	17.39	0.0	31.55	0.0
1.01	1.57	99.5	17.3	0.1	31.4	0.1+
1.02	3.03	99.1	17.2+	0.2−	31.3	0.2
1.03	4.49	98.7	17.2−	0.2+	31.1	0.4
1.04	5.96	98.2	17.1	0.3	30.9	0.6
1.05	7.37	97.5	17.0	0.4	30.7	0.8
1.06	8.77	96.9	16.9	0.5	30.5	1.0
1.07	10.19	96.2	16.7	0.7	30.3	1.2
1.08	11.6	95.6	16.6	0.8	30.1	1.4
1.09	12.99	94.8	16.5	0.9	29.9	1.6
1.10	14.35	93.9	16.3	1.1	29.6	1.9
1.11	15.71	93.2	16.2	1.2	29.4	2.1
1.12	17.01	92.3	16.1	1.3	29.1	2.4
1.13	18.31	91.2	15.9	1.5	28.7	2.8
1.14	19.61	89.9	15.6	1.8	28.3	3.2
1.15	20.91	88.8	15.4	2.0	28.0	3.5
1.16	22.19	87.4	15.2	2.2	27.5	4.0
1.17	23.47	85.7	14.9	2.5	27.0	4.5
1.18	24.76	84.0	14.6	2.8	26.5	5.0
1.19	26.04	82.3	14.3	3.1	25.9	5.6
1.20	27.32	80.5	14.0	3.4	25.4	6.1
1.21	28.58	78.7	13.7	3.7	24.8	6.7
1.22	29.84	76.7	13.3	4.1	24.2	7.3
1.23	31.11	74.6	13.0	4.4	23.5	8.0
1.24	32.28	72.5	12.6	4.8	22.8	8.7
1.25	33.43	70.4	12.2	5.2	22.2	9.3
1.26	34.57	68.0	11.8	5.6	21.4	10.1
1.27	35.71	65.5	11.4	6.0	20.6	10.9
1.28	36.87	63.1	11.0	6.4	19.9	11.6
1.29	38.03	60.7	10.6	6.8	19.1	12.4
1.30	39.19	58.3	10.1	7.3	18.4	13.1
1.344	44.0	49.0	8.5	8.9	15.5	16.0
1.361	46.0	45.0	7.7	9.7	14.5	17.0
1.380	48.0	42.0	7.1	10.3	13.4	18.1
1.398	50.0	38.0	6.5	10.9	12.0	19.5
1.417	52.0	33.0	5.8	11.6	10.9	20.6
1.438	54.0	29.5	5.0	12.4	9.5	22.0
1.459	56.0	25.0	4.3	13.1	8.1	23.4
1.479	58.0	21.5	3.5	13.9	7.2	24.3
1.503	60.0	18.5	3.0	14.4	6.1	25.4
1.524	62.0	15.5	2.6	14.8	5.0	26.5
1.546	64.0	12.7	2.2	15.2	4.0	27.5

Table showing approximate relative humidity, vapor pressure, and saturation deficit at 20° and 30° C. for dilute sulphuric acid of various specific gravities.—Continued

SPECIFIC GRAVITY	PERCENTAGE H_2SO_4 IN THE SOLUTION	APPROXIMATE RELATIVE HUMIDITY	VAPOR PRESSURE AT 20°C.	SATURATION DEFICIT AT 20°C.	VAPOR PRESSURE AT 30°C.	SATURATION DEFICIT AT 30°C.
		per cent	*mm. of mercury*		*mm. of mercury*	
1.569	66.0	10.5	1.8	15.6	3.5	28.0
1.592	68.0	9.0	1.5	15.9	3.0	28.5
1.615	70.0	7.5	1.3	16.1	2.5	29.0
1.639	72.0	6.0	1.0	16.4	2.0	29.5
1.662	74.0	4.5	0.6	16.8	1.7	29.8
1.690	76.0	3.5	0.5	16.9	1.4	30.1
1.710	78.0	3.0	0.4	17.0	1.1	30.4
1.732	80.0	2.5	0.3	17.1	0.8	30.7
1.754	82.0	1.5	0.2	17.2	0.5	31.0

SATURATION DEFICIT AND RELATIVE HUMIDITY COMPARED

The point has been frequently raised (4: 64–68; 9: 114; 8: 2–7) that saturation deficit, i.e., the difference between the observed vapor pressure and the maximum vapor pressure possible at the same temperature, is a more satisfactory expression of atmospheric humidity than is relative humidity, i.e., the ratio between the observed vapor pressure and the vapor pressure at saturation under the same conditions of temperature. The relation between these two expressions is discussed by Hann (6: 49; 7: 161) and illustrated as follows. If E denotes the vapor pressure at saturation, e the observed vapor pressure, the relative humidity is the quotient of $e \div E$ and the saturation deficit the difference, $E - e$. The saturation deficit is therefore equal to (1 − relative humidity)E. Evidently, then, for the same relative humidity the saturation deficit increases with the temperature, because E(vapor pressure at saturation) increases very rapidly with the temperature.[2] Meyer (9: 115) and Deneke (4: 68) give tables by means of which the saturation deficit can be derived from air temperature and relative humidity.

It is correctly urged by the advocates of saturation deficit that a given percentage of relative humidity, for instance, 75, has very different meanings when the temperatures differ, and in order for relative humidity to have any real significance it is always necessary to take into account the temperature prevailing at the time. In saturation deficit the factor

[2] Hann (6: 48–49) points out that by fortunate coincidence in the case of temperatures usually occurring out of doors the vapor pressure in millimeters and the weight of water vapor in grams per cubic meter are expressed in almost the same figures. If this is true, it is evident that saturation deficit as given in table 1 may be considered as roughly indicating the weight of water in grams which a cubic meter of air lacks of saturation. The approximation is closest at 20°C.

of temperature is included and rapidity of evaporation is much more nearly proportional to the saturation deficit than to the relative humidity.

On the other hand, Hann (6: 47–66) contends that relative humidity is preferable as a means of expressing climatological facts, because it is more readily understandable and has a closer relation to physiological reaction. From the context it is evident that he refers to human physiology and is evidently using the term to include psychological and temperamental relations. It is, however, not yet certain that the effect of atmospheric moisture even in plant physiology is entirely a matter of rate of evaporation. Perhaps, therefore, it would be well to follow Hann's suggestion and retain for the present both expressions, meanwhile trying to determine which one more nearly expresses the relation of plant processes to the moisture of the air. The fact should be constantly borne in mind that relative humidity without the corresponding temperature data is practically meaningless and in studies of plants, temperatures should always be given.

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A PYTHIACYSTIS ON AVOCADO TREES

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In May, 1914, part of a diseased trunk of an avocado tree was received from K. A. Ryerson, a student at the University of California, with a request for information regarding the nature of the trouble. The bark was killed and slightly sunken over an area twenty centimeters in length and seven centimeters (one-half the circumference) in greatest width. A gum had exuded and hardened in small beads on the surface, and in addition a white, powdery, crystalline substance was deposited over the surface at the lower part and below the diseased area. The freshly killed bark and wood were still firm, not soft or watery. The wood was affected only a few millimeters entad. This was typical, as was afterwards learned, of a bark disease occasionally occurring on avocados in a number of localities. The following information regarding its occurrence was obtained from Mr. Ryerson. The disease occurs most often on the trunk not far from the surface of the soil, but occasionally it is found higher on the trunk and also on limbs where it commonly begins at the base of a leaf. It occurs not only on the trunks of larger trees, but is found on small seedlings especially if they have been overwatered. This disease, while not of frequent enough occurrence to result in serious damage unless on particularly valuable trees, is likely to appear suddenly and spread fairly rapidly in spite of care exercised to check it.

Three culture tests were made from this specimen received from Mr. Ryerson, by first flaming the surface, then cutting off the outer bark, flaming again, cutting out small bits of the bark and wood from the junction of the dead and live tissue, and dropping them into slant corn meal agar tubes. A species of Pythiacystis developed in the three tubes.

In July, 1914, another specimen of an affected avocado limb which had been unsuccessfully treated by cutting away the diseased bark and disinfecting the area, was sent from the same locality. The bark had begun to heal at the cut edges, but the wood underneath was dark in color. The same fungus was again isolated from three different places in the darkened wood five millimeters from the surface and in one case ten centimeters beyond the point where the bark had been cut away for treatment. In five out of six tubes, made as before, a Pythiacystis developed.

On October 6, 1914, the trunks of two Mexican seedling avocado trees at the Whittier Laboratory were inoculated with this species of Pythiacystis by inserting into longitudinal cuts, two centimeters long, bits of the mycelium from a culture. The cuts were then covered with paraffined paper which were held with raffia. On one tree a cut of the same kind was made and covered as the others to serve as a check.

When the inoculated trunks were first examined on October 22, 1914, a watery, slightly colored liquid was exuding from both cuts, and below one lesion the white crystalline substance, seen on the original specimen, was being deposited as the exuding liquid dried. The check cut was already beginning to heal without any deposit.

On January 14, 1915, a considerable deposit of the white crystalline substance had formed at both of the inoculated cuts and the larger area of killed bark was two centimeters wide and six centimeters long. The wood was affected only a few millimeters in depth. The affected bark and wood was cut out to save the trees and four culture tests made as described before from the advancing edge of one of the diseased areas. In three of the culture tubes a Pythiacystis developed. The incision on the check tree healed rapidly without apparent injury to the adjoining bark.

One of the original cultures was kept alive by subcultures, and on March 28, 1916, further inoculations were made into avocado trunks with it and also with *Pythiacystis citrophthora* S. & S. isolated from the bark of a lemon tree affected with gummosis. Two inoculations from each culture were made and two additional cuts were made to serve as checks. All were wrapped in the same manner as in the previous inoculations. All inoculated cuts were showing the white crystalline deposit by April 7, 1916, and the bark about the cuts was discolored. On May 15, a large deposit of this white substance had formed below all the inoculated cuts. The effect on avocado of the Pythiacystis from lemon was about the same as of the species of Pythiacystis affecting avocado. A diseased area of each kind was cut out. They showed the cambium killed over an area two centimeters wide and five centimeters long. The avocado Pythiacystis was again recovered from the advancing edge of a diseased area. The cuts serving for checks healed rapidly without apparent injury to the tree.

The same two cultures were tested on young orange trees at the same time. The lemon Pythiacystis produced gummosis on the orange with killing of bark adjacent to the cut. The avocado Pythiacystis, however, produced no effect, the cuts healing almost as rapidly as the checks.

That a Pythiacystis, similar to *Pythiacystis citrophthora*, may under certain conditions become at least a wound parasite of avocado trees, is shown by these tests. The fungus was isolated from two different

specimens, was grown in pure cultures, was introduced into trunks of avocado trees at two different seasons and produced effects similar to those on the trees from which it was isolated. It was twice recovered in cultures from the inoculated trees, in one case six weeks later and in another three months after the inoculation.

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SCLEROTINIA LIBERTIANA ON SNAP BEANS[1]

J. A. McCLINTOCK

WITH TWO FIGURES IN THE TEXT

Early in November, 1915, the Virginia Truck Experiment Station was notified of a rather serious loss in a fall crop of snap beans (*Phaseolus vulgaris*) on one of the large truck farms of this section.

There were thirty acres of beans in several fields on this farm. The fields were separated from each other by tall hedges. Over large areas in some of the fields no beans were picked because the plants had not developed sufficiently to produce marketable pods. On these stunted plants many small, withered or partly decayed pods more or less covered with white mycelium and small, hard, sclerotial masses were observed as shown in figure 1. Many of the plants also bore white mycelium and sclerotia on their stems and branches as shown in figure 2.

The beans were planted late in July between rows of strawberry plants and grew well until five or six weeks of age. At this time, i.e., early in September, there was a period of three or four days of hot, humid weather. Immediately following this period, in areas where the plants stood thickest, the plants began to show signs of trouble with withering and decay of stems, leaves and pods. The disease spread rapidly in the fields with the result that instead of getting six thousand baskets of beans, as expected, the total crop was about four thousand baskets.

Specimens of diseased plants were taken to the laboratory on November 9, 1915. Sections of diseased stems and pods were externally disinfected for five minutes in 1 to 1000 mercuric chloride, and then transferred to sterilized petri dishes. Lima bean agar was poured over these sections. On November 15, 1915, an organism, similar in appearance to the one on the bean plants, was obtained from a section of pod plated November 9.

INOCULATIONS ON LETTUCE

As the organism producing the abundant, black sclerotia in culture appeared similar to the organism which had previously been isolated from diseased lettuce (*Lactuca sativa*), inoculations with the organism

[1] While this work was in progress the writer was interested to see Dr. Barrus' article "An Anthracnose-resistant Red Kidney Bean" in Phytopathology **5**: Nov. 1915, p. 303, in which he mentions *Sclerotinia libertiana* as the occasional cause, when the weather is especially favorable, of a brown rot of beans.

from beans were made on lettuce to see if it would produce typical lettuce drop. On November 27, 1915, with culture 1 the following inoculations were made: (1) Four large lettuce plants in individual pots were wounded on the stems just below the surface of the soil, and one sclerotium from culture was applied to each wounded stem and covered with soil. Similar plants were wounded and kept as checks. Both inoculated

FIG. 1. Diseased bean pods showing white mycelium and sclerotia of *Sclerotinia libertiana*.

plants and checks were placed in moist chambers. (2) One pot of twenty-five seedling lettuce plants was inoculated by placing one sclerotium on the soil between two plants. (3) Four large lettuce plants in individual pots were inoculated by slashing the stems at the surface of the soil and applying bits of mycelium to the wounded tissues. (4) Thirty seedling

lettuce plants in another pot were inoculated by placing bits of mycelium on the soil in contact with the stems. The plants of this second series were not covered with bell-glasses.

The results were as follows: (1) Of the four large lettuce plants inoculated with sclerotia, one plant showed typical drop on December 9, a second on December 10 and the remaining two on December 18. (2) All of the twenty-five seedling plants inoculated with sclerotia showed

FIG. 2. Diseased bean plant showing mycelium and sclerotia of *Sclerotinia libertiana* on stem and branches.

drop on December 10. (3) The four large plants inoculated with mycelium remained healthy. (4) The thirty seedling plants inoculated with mycelium showed typical drop on December 13.

In the case of the four large lettuce plants which were inoculated with mycelium but which were not placed under bell-glasses, it appears that the mycelium dried before it gained a foothold on the more mature tissues; the plants, therefore, remained healthy.

As the check plants remained healthy, it appeared that the organism from the bean was probably a strain of *Sclerotinia libertiana* Fckl. because its effect on the lettuce plants and the production of typical sclerotia in the axils of the leaves were similar to those of *Sclerotinia libertiana*.

INOCULATIONS ON BEAN PLANTS

To determine whether or not this Sclerotinia was parasitic on beans the following inoculations were made: (1) On December 4, 1915, three bean plants, two weeks old, were inoculated from a sub-culture made November 26, 1915, by applying bits of mycelium to the slashed cotyledons. Two similar plants in the same pot were inoculated by applying bits of the fungus to the wounded stems at the surface of the soil. This pot of five plants was placed under a bell-glass. (2) Five bean seedlings in a second pot were treated as above except that the plants were not injured before applying bits of the fungus to stems and cotyledons. This pot was also placed under a bell-glass.

The five seedling bean plants of a third pot were slashed about the stems and cotyledons to serve as checks.

On December 7, 1915, one of the bean plants inoculated on the slashed cotyledon had become so badly decayed on the stem at that point as to topple over. Abundant white mycelium was present over the surface of the other bean plants at the points of inoculation. The host tissues at these points had become water-soaked in appearance.

On December 8, 1915, five days after inoculation, the two bean plants inoculated on the slashed stems and also the other two plants inoculated on the cotyledons had decayed at the points of inoculation and fallen over. On the same date two plants of pot 2 which were inoculated on the uninjured stems had also begun to decay at the point of inoculation. The pot of check plants showed no sign of disease.

These tests proved that the Sclerotinia obtained from bean plants from the field was pathogenic to both bean plants and lettuce plants, and it was concluded that it was this Sclerotinia which had produced the trouble in the bean fields.

On December 9, 1915, three five-days-old bean plants, growing in one pot, were inoculated by placing bits of the bean Sclerotinia in contact with the cotyledons which were just pushing through the surface soil. A similar pot of seedlings served as check. These two pots were not placed under bell-glasses.

On December 18, 1915, the three bean plants inoculated ten days previously had begun to decay at the base of the stem. The check plants remained healthy.

Comparing plants in this test with plants similarly inoculated but placed under bell glasses it is seen that it took twice as long for the same organism to produce decay when the inoculated plants were not placed under bell-glasses, thus indicating that humidity is an important factor in the spread of this organism.

During December, 1915, two more collections of specimens were made from the same farm. In each case, sclerotia removed from the diseased stems and pods when externally disinfected in 1 to 1000 mercuric chloride and plated on agar yielded the white mycelium and black sclerotia. Material from sub-cultures of the above placed in contact with the stems of seedling bean plants resulted in the typical decay. Reisolations from these artificially infected plants yielded a Sclerotinia similar to that obtained from the field plants.

It was noticed that in culture the sclerotia from the bean-disease fungus differed considerably in size and shape from sclerotia produced by the lettuce-drop organism. Further work is under way to determine whether or not there are similar differences between the ascosporic stages of these two organisms.

VARIETAL RESISTANCE

Two varieties of snap-bean seed were used on this farm, one a black seeded variety known under the trade name of Black Valentine, the other a red or spotted seeded variety, known as Red Extra Early Refugee.

According to the observations of the owner of the farm, the Red Extra Early Refugee was much more susceptible to this trouble, due, probably to its more rapid and tender growth. Artificial inoculation tests, however, proved that both varieties were readily attacked by the Sclerotinia isolated from the bean plants. Several other varieties of snap-bean seed have been obtained and tests are now being made to determine whether or not any of the varieties show marked resistance to this Sclerotinia.

Prior to planting the fields to a fall crop of snap beans, spring crops of snap beans and garden peas had been grown. These plants are known to be hosts of *Sclerotinia libertiana*, so the fungus was probably present here and there over these fields, in the form of sclerotia, awaiting suitable conditions for parasitic development.

There is reason to believe that in the warm, humid climate of eastern Virginia this organism may become a serious menace to snap bean growing unless the growers take steps to free their soil from it by proper rotation of crops.

SUMMARY

A serious disease in a fall crop of snap beans was found to be due to a Sclerotinia.

Cross inoculations proved that this Sclerotinia was able to produce typical lettuce drop.

The fungus required twice as long in dry air as in humid air to produce typical decay, thus showing that moisture is an important factor in its spread.

Some evidence of difference in varietal resistance was observed in the field.

In culture the Sclerotinia isolated from beans produced sclerotia which differed in size and shape from sclerotia produced in culture by the lettuce-drop organism, thus suggesting that the former organism is a special strain of *Sclerotinia libertiana* Fckl.

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CITRUS SCAB

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The writer wishes to discuss some features of Grossenbacher's article entitled, Sour scab of Citrus in Florida, and its prevention.[1]

One questions in the first place the advisability of ignoring the common names scab and verrucosis used by Swingle and Webber[2] and well established in the later literature on the subject, and of using the misleading term, sour scab. This name would seem to convey the impression that the disease tends to make fruit affected by it sour, or that it is confined to the sour orange or to very acid fruits, which is by no means the case. While the sour orange and lemon are, to be sure, two of the most susceptible varieties in Florida, the Satsuma orange is also susceptible. It would seem that common names of plant diseases well established in literature should not be changed without sufficient reason.

A discussion by Grossenbacher of the various possible factors related to the cause of scab, such as high acidity induced by wet, cold weather with resulting high osmotic pressure, exuded aromatic substances absorbed by films of water on the leaves, oil liberated from glands on the surface and so forth, is followed by the statement: "The tangible evidence in support of the idea universally held, that *Cladosporium citri* causes sour scab, is slight and inconclusive. In fact, the evidence to the contrary is even stronger."

In another place it is stated: "It is an interesting fact that sour scab has always been attributed to the fungus *Cladosporium citri*, and that some of the inoculation experiments performed by Fawcett upheld the assumption that this fungus is the cause of the disease, while others were either negative or neutral."[3]

Attention should be called to this "evidence to the contrary" presented in Grossenbacher's paper. It is stated first that a doubt developed during field observations in 1913–14 regarding the correctness of this "hypothesis"; then that inoculation tests repeated three times during three different growth periods in 1915 failed to produce a single indication of the disease on rapidly growing sour-orange and grapefruit seedlings.

It appears quite evident from another part of the paper, where statements are given of the appearance and occurrence of the fungus with

[1] Phytopath. **6** : 127–142, April, 1916.

[2] Swingle, W. T., and Webber, H. J. Principal diseases of citrous fruits in Florida. U. S. Dept. Agr., Div. Veg. Phys. Path. Bul. 8: 20–24. 1896.

[3] Fawcett, H. S. Citrus scab. Florida Agr. Exp. Sta. Bul. 109: 51–60. 1912.

which Grossenbacher was making these inoculation tests, that he was using the common saprophytic Cladosporium of the *C. herbarum* type, which is almost universally present on old scabs, instead of the less conspicuous, true scab fungus to be found on the early-stage scabs of the rapidly developing tissue. Grossenbacher apparently overlooked the fact that *Cladosporium citri* Massee, as described in cultures in Bulletin 109 previously referred to, is not an ordinary Cladosporium and is not what is ordinarily seen with the unaided eye on the old scabs. It was from the early stages, on which Grossenbacher states the fungus was usually not found, and not from the later ones, that I found it was possible to isolate *Cladosporium citri*. The Cladosporium on the older scabs which could be "selected with the unaided eye because of the dark-fruiting fungus," was, according to my experience, a pure saprophyte and not the fungus used in my inoculation tests. No mention is made of the fungus he had being an unusual Cladosporium, but emphasis is laid on the ease with which scabs could be selected with the unaided eye from which the Cladosporium he used could be isolated.

But even if the right fungus were isolated from the old scabs, the negative results of three different tests at three different times mean little without a statement of the conditions under which the inoculation experiments were made. In another part of the paper a great deal of emphasis (and that rightly) is laid on the special conditions necessary for the occurrence of scab. But in giving these negative results as evidence, the only condition stated is that the trees were growing vigorously. Some weight appears to be given to the fact that some of the results obtained by the present writer were negative. These negative results were included in the publication of the experiments in Bulletin 109 for what they were worth in indicating that at first only part of the conditions for infection in the greenhouse experiments were satisfied. At first negative results were obtained in spraying on spores from pure cultures, even though one of the necessary conditions for infection, vigorous growth, was satisfied. Later positive results were obtained under the same procedure, due it would seem to combining abundant moisture on the surface of the leaves with vigorous growth. The plants used as checks remained free from scabs in each case.

An experiment is also described in the paper by Grossenbacher under the discussion of the cause, in which sour orange trees were cut back and scrubbed with corrosive sublimate and then covered with cheese-cloth stretched about four stakes driven in the ground, the top and bottom also being covered with cheese-cloth. It is stated that the trees under the cheese-cloth had later practically as much scab on the leaves as the checks not covered. If this experiment were meant to have a bearing on the question of whether or not scab is due to an organism as

seems probable (otherwise the scrubbing with corrosive would scarcely have been necessary) it is difficult to see what value the experiment has in this connection. It is scarcely necessary to point out that the dimensions recorded for spores of *Cladosporium citri* Massee are such that 100 to 200 could pass abreast through a single mesh in ordinary cheese-cloth without touching the threads on either side. And even assuming that cheese-cloth might be a partial filter for spores when dry, if the experiment were in the open the frequent rains of summer in Florida would carry innumerable spores through the meshes in drops of water.

It is difficult to ascertain from the experiments and observations presented in the paper, wherein the "evidence to the contrary is even stronger." That the "cause becomes obscured rather than clarified" in the mind of this author appears to be due to an oversight as to the true nature of the scab fungus and consequently to a failure to find or isolate the organism in the earlier stages of the scabs.

Cladosporium citri is not an ordinary Cladosporium, a fact I attempted to point out in some detail in Bulletin 109 of the Florida Agricultural Experiment Station. I considered at that time that Scribner had figured the right fungus and that Massee[4] had distinguished it from the other forms though both had confused the description in part at least with a saprophytic Cladosporium. A further study of this fungus in cultures is being made with the purpose of later placing it if possible more nearly in its proper relationship.

It may be of interest to note that some further very carefully controlled inoculation tests on sour-orange seedlings with pure cultures of this fungus, made subsequent to the publication of Bulletin 109 of the Florida Agricultural Experiment Station, have confirmed the results there reported. Ten trees were used in the experiment. Five trees used as controls were equal in age and growth to those inoculated. All were first sprayed with water. Then a camel's hair brush moistened with distilled water was drawn over the rapidly growing leaves of the check trees, and another camel's hair brush moistened with a suspension of spores from pure cultures of the fungus was drawn over the rapidly growing leaves of the others. In every other way the five check trees were treated in exactly the same way, tree for tree, as the inoculated ones. All trees were kept sufficiently well watered for normal growth. Two inoculated trees with their two corresponding checks were kept in a closed room of the greenhouse with high humidity and temperature between 20° and 35°C. A third tree and its corresponding check were covered 24 hours with bell jars after which they stood in a well ventilated greenhouse at

[4] Massee, G. Diseases of cultivated plants and trees. The Macmillan Company, New York, p. 474. 1910.

15° to 30°C. A fourth tree and its corresponding check were covered with bell jars for 48 hours, after which they stood in front of a closed window of the laboratory at 15° to 28°C. A fifth tree and its check were kept outside under bell jars during the entire time of the experiment, but protected from the direct rays of the sun, at about 15° to 28°C. The leaves on each control had the same opportunity as the inoculated ones to be influenced by high acidity, high osmotic pressure, exuded aromatic substances absorbed by films of water on the leaves, oil liberated from the glands, etc., but not a single scab developed on their leaves. Those trees inoculated by drawing a camel's hair brush moistened with a water suspension of spores over their leaves, however, developed in from two to three weeks numerous typical scabs on which spores of the fungus were present in great numbers and from which pure cultures of the fungus were again obtained. The first indication of infection appeared in from six to eight days.

Grossenbacher's paper is valuable in calling attention in considerably more detail than previous papers to the special conditions and possible contributing factors influencing the occurrence and severity of scab. It also confirms the work of Swingle and Webber and others in showing that the disease yields readily to spraying with Bordeaux mixture, and also confirms some experiments of Yothers', published in the *Florida Grower*, in showing that lime-sulfur is also a preventive. The distinct contribution in his paper is the additional data obtained by a large number of spraying experiments with Bordeaux and lime-sulfur, as to the time when spraying is effective, the number of times necessary for efficient prevention and the actual losses from the disease in scabby fruits. These data are of great practical value.

Prof. Wm. T. Horne informed the writer that several years ago he had occasion to make some small studies on citrus scab. He writes "Trees of Dancy tangerine were readily infected in the greenhouse by placing material from scabs in drops of water on young leaves and covering the inoculated plants with bell-glasses. The plants were then kept very moist for several days. Typical scabs were produced, bearing spores characteristic of the so-called *Cladosporium citri*. No new scabs from natural infection were observed, although close watch was kept, the plants remaining in the greenhouse throughout the experiments. The inoculations were repeated several times with uniformly successful results and the material was then destroyed. Believing the relation of citrus scab and the so-called *Cladosporium citri* to be established and since the experiments were not planned to prove pathogenicity, no note was published of these studies."

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PHYTOPATHOLOGICAL NOTES

Pycnia of Cronartium pyriforme. So far as is known, the pycnia of *Cronartium pyriforme* (Peck) Hedgc. & Long have never been found.

On July 21, 1916, near Castella, Shasta County, California, at an elevation of 2200 feet, a few western yellow pine (*Pinus ponderosa* Laws.) seedlings and small saplings were found with typical, spindle-shaped or fusiform swellings on the main stem.[1] On one of these trees the aecia had already sporulated, while from two others drops of a Brazil-red,[2] clear, sweet, sticky liquid were exuding, which upon examination proved to contain innumerable pycnospores. There was no exudation from the swelling with the aecia. All these seedlings were standing within from one to five feet of *Comandra umbellata* bearing uredinia and telia.

The following description is based on field notes and the examination of collected material:

Pycnia caulicolous, scattered, subepidermal, forming small, bladder-like swellings, exuding a clear, sweet, sticky, Brazil-red liquid; pycnospores hyaline, commonly pyriform, (50) 3 to 4 by 3 to 7 μ (3 by 4).[3]

A certain analogy in the shape of the pycnospores and aeciospores is of interest. The great majority of the pycnospores were pyriform, even more truly so than the aeciospores, without taking on the extreme drawn-out, pointed shapes sometimes found in the latter. There was no reason to assume that this peculiarity of form could have been due to partial germination of the pycnospores. A few were ovoid or somewhat elongated.

The period elapsing between infection and appearance of pycnia and aecia will have to be exactly determined by artificial inoculations in the field but from the results of observation the following hypothesis may be advanced. In the region under consideration at the given elevation the aecia usually commence sporulation in late April or early May and finish by late June or early July, while telia on the Comandra are first sparingly produced in early July, do not become abundant until late July, and then continue until autumn. It seems, therefore, highly improbable that the

[1] Hedgcock, George G., and Long, William H. A disease of pines caused by Cronartium pyriforme. U. S. Dept. Agr. Bul. 247: 14. 1915.

[2] Ridgway, Robert. Color standards and color nomenclature, Plate I. 1912.

[3] Meinecke, E. P. Spore measurements. Science n. s. **42**: 430. 1915.

pycnia found in this locality could have been the result of an infection by sporidia during the current season but more probably of at least one previous season. Since one tree was found on which the aecia had already sporulated but no pycnia were in evidence, and since the two trees with pycnia showed no signs of developing aecia, the assumption seems justified that the aecia do not appear until the season following the appearance of the pycnia. To sum up then, the pines are probably infected in the summer or fall of one season, pycnia do not appear until the summer of the next season at the earliest, while mature aecia are produced in the late spring or early summer of the third season. J. S. BOYCE

Phytophthora infestans on tomatoes in Australia. The attention of the writer has been called by Dr. C. C. Brittlebank, of Melbourne, Australia, to an error of citation in a recent article by F. D. Kern and C. R. Orton[1] entitled "*Phytophthora Infestans* on Tomatoes." The citation in question is to the paper by N. A. Cobb, published in the Agricultural Gazette, N. S. W. **13**: 410–414, 1902. Dr. Brittlebank states that this paper by Cobb contains no report of Phytophthora so far as he can discover and he further states that the disease in question was not discovered on tomatoes in Australia until 1909 in Queensland, 1910 in New South Wales, and 1911 in Victoria. Dr. Brittlebank states that in Victoria the fruit is infected to a far greater extent than the leaves or stems. The citation was not taken from the original but from Bulletin 192 of the Virginia Agricultural Experiment Station, at the bottom of page ten. This note is written to correct this error so far as possible. C. R. ORTON

Leaf roll in tomatoes? At Lethbridge, Alberta, (Canada) test rows of tomatoes showed a phenomenon which closely resembled "leaf roll" in potatoes. The leaves of a number of plants showed a very pronounced "roll," while some plants of the same variety showed normal leaves only. The "roll" began from below and proceeded in an upward direction. The plants were trained on stakes and thus showed up well. Some years ago Dr. Gustav Köck[2] called attention to a similar occurrence in Austria. Dr. Köck failed to find any parasitic organism in his specimens; those at Lethbridge appeared sound with the exception of the rolling of the leaves (September, 1916). H. T. GÜSSOW

Celluloid cylinders for inoculation chambers. In the course of work on cultures of forest tree rusts and in inoculation experiments in general, it

[1] Phytopath. **6**: 284-287. 1916.
[2] Wiener landwirtschaftl. Zeitung, no. 89. November 8, 1911.

became evident that a substitute must be found to replace heavy bell-glasses and other similar vessels in isolating the inoculated plants. This was necessary since it was desired to supplement greenhouse work with experiments in the field, often on leaves, twigs, or branches of large plants. Inoculations of this nature barred the use of the ordinary methods

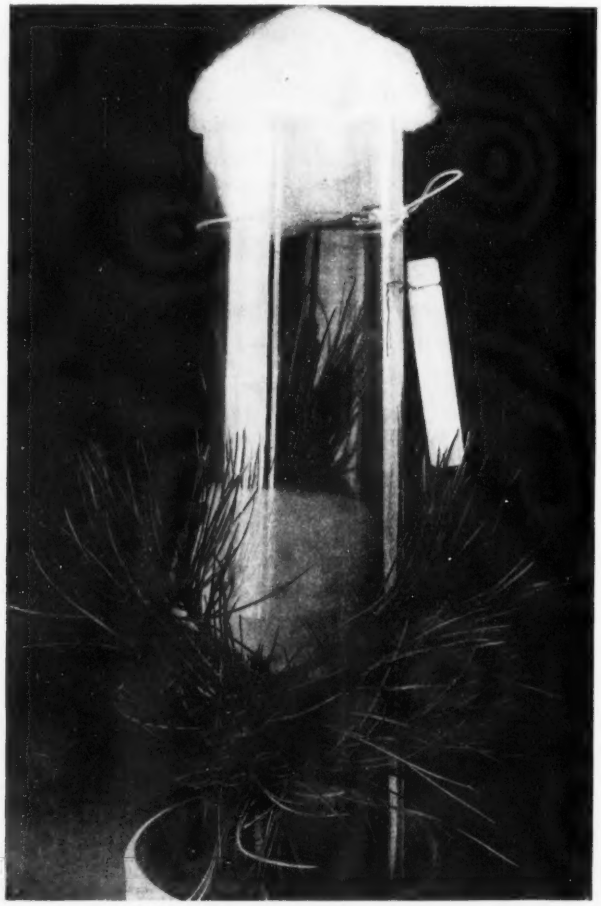

FIG. 1. Celluloid inoculation cylinder

with heavy glassware. Entire immunity from exterior contamination was desired for that portion of the plant treated as well as the free entrance of light, a limited circulation of dust-free air, and the retention of a certain amount of moisture. To meet this demand cylinders of hard

clear glass were first employed[1] in a number of field experiments with much success. The method of procedure was the same as that described below for celluloid cylinders.

The increase in the number of experiments on the larger plants in the greenhouse made the cost of sufficient glass coverings prohibitive; also proper glass cylinders were found to be difficult to procure beside being easily broken. For inoculations on plants of different size and on parts of large plants a large number of cylinders of various dimensions were desired which should be flexible, transparent, non-fragile, and of light weight. Several devices were considered but none proved of any practical value with the exception of those cylinders made of ordinary sheet celluloid such as is used for windows in automobile tops and sold under the name of transparent celluloid. The thinner of the two grades of celluloid proved excellently adapted to the purpose in hand.

Cylinders of various lengths and diameters were made of this material, the edges being fastened together by means of acetic ether (ethyl acetate) applied by dipping a camel's hair brush in the liquid and running it quickly along the edges to be cemented. The acetic ether dissolves the celluloid sufficiently to form a tight joint when the liquid evaporates and if the two surfaces are kept pressed together until dry the resulting cylinders will be found to be durable.

These cylinders were slipped over branches and growing tips before inoculation, or over branches before the leaves appeared. The openings at either end were plugged with cotton and a small wad of moistened cotton was left on the branch inside the cylinder to provide sufficient moisture. Whenever necessary a split cedar splinter and a bit of string were used to support the cylinder with enclosed branch in its normal position. A small square of celluloid with a short piece of flexible wire attached can be cemented to the side of the cylinder and serve in place of a string. These formed ideal inoculation chambers (fig. 1) entailing small expense and labor and apparently interfering very little with the normal activities of the trial host. The usual care, however, must be exercised in regard to shading the inoculated plants when exposed to the direct rays of the sun. The greenhouse at Missoula where these cylinders were tried out is constructed with a roof having the south exposure of opaque material and letting in light only through the north side. They provided light, air, and sufficient moisture for successful inoculation, excluded troublesome insects and seed eating birds in the case of mistletoe experiments, and kept all other forms of inoculations and cultures successfully isolated.

[1] Weir, J. R. Phytopath. **5**: 218, August, 1915.

Large cylinders covering the entire plant were made for use on herbaceous plants and tree seedlings and proved quite equal to and even better in some instances than large glass bell-glasses or large glass cylinders.

ERNEST E. HUBERT

Personals. The Department of Botany of the Massachusetts Agricultural College and Experiment Station has been reorganized with the following personnel:

A. Vincent Osmun, Professor and Head of the Department; George H. Chapman, Research Physiologist; P. J. Anderson, Associate Professor and Associate Pathologist; Orton L. Clark, Assistant Professor and Assistant Physiologist; F. A. McLaughlin, Instructor; G. W. Martin, Instructor.

LITERATURE ON AMERICAN PLANT DISEASES

COMPILED BY EUNICE R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY AND FLORENCE P. SMITH, ASSISTANT

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Apparently a physiological disease having much in common with gummosis.

[PHYTOPATHOLOGY, for October, 1916 (**5**: 381–418), was issued October 10, 1916.

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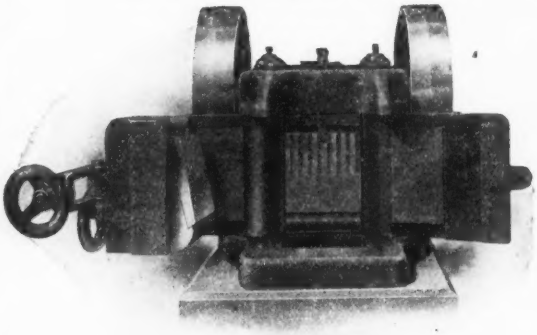

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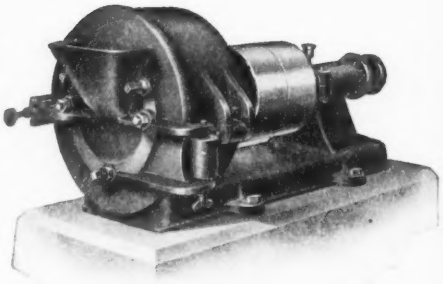

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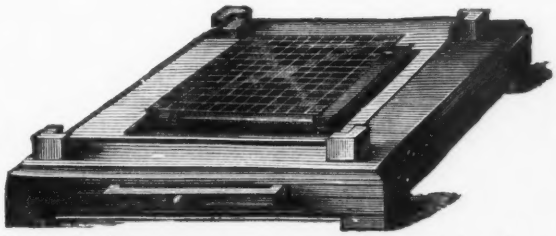

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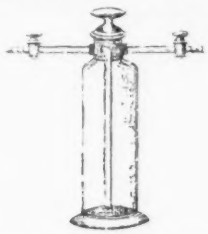

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